AN OPTICAL-IR COUNTERPART FOR SGR B1900+14?

F. J. VRBA, C. B. LUGINBUHL
U.S. Naval Observatory Flagstaff Station, P.O. Box 1149, Flagstaff AZ 86002-1149, USA
D. HARTMANN
Department of Physics and Astronomy, Clemson University, Clemson SC, USA
K. HURLEY
University of California, Space Sciences Laboratory, Berkeley CA, USA
S. KULKARNI, M. VAN KERKWIJK
California Institute of Technology, Pasadena CA, USA
R. PROBST
National Optical Astronomy Observatory, Tucson AZ, USA
I. SMITH
Rice University, Houston TX, USA
and
C. KOUVELIOTOU, C. MEEGAN, G. FISHMAN
Marshall Space Flight Center, Huntsville AL, USA

Abstract. A deep optical search of the "Network Synthesis" localization for the SGR B1900+14 and the nearby ROSAT source error box has yielded an unusual source positionally coincident with an IRAS source. We present optical and IR data describing this source.
Key words: Soft Gamma-Ray Repeater SGR B1900+14 – SGR Optical Counterparts

1. Introduction

Of the three known soft gamma-ray repeaters (SGRs), two have been identified with supernova remnants: one in the Galaxy and one in the Large Magellanic Cloud (Kulkarni and Frail, 1993; Cline *et al.*, 1982). Recently, the remaining known member of the class, SGR B1900+14 (Kouveliotou *et al.*, 1993), has been localized using the network synthesis technique (NST) (Hurley, *et al.*, 1994) to a region close to the Galactic radio SNR G42.8+0.6. Vashisht *et al.* (1994) report that a ROSAT source lies just outside of the NST localization, and tentatively identify it with the SGR. In this paper we report the discovery of an extremely red optical and near-IR source within the ROSAT error box and less than one arcminute outside the $\sim 13 \times 1$ arcminute NST error box. This optical/near-IR source is coincident with an IRAS source.

2. Observations

We have obtained CCD UBVI imaging of the areas including the NST and ROSAT error boxes, using a Tektronics 2048×2048 thinned CCD camera at

Astrophysics and Space Science **231**: 85–88, 1995.
© 1995 *Kluwer Academic Publishers. Printed in Belgium.*

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 1995		**00-00-1995 to 00-00-1995**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
An Optical-IR Counterpart For SGR B1900+14?	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Naval Observatory Flagstaff Station,P.O. Box 1149,Flagstaff,AZ,86002**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
A deep optical search of the "Network Synthesis" localization for the SGR B1900+14 and the nearby ROSAT source error box has yielded an unusual source positionally coincident with an IRAS source. We present optical and IR data describing this source.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**5**	

the USNO 1.0-m and 1.5-m telescopes in Flagstaff. We have also made near-IR JHK observations using the SQIID camera at the KPNO 1.3-m telescope and the USNO IRCAM at the USNO 1.55-m telescope.

Figure 1 shows the NST and ROSAT error boxes on a CCD I-band image taken at the 1.0-m telescope. Figure 2a shows a portion of another CCD I image taken at the 1.5-m telescope, showing the region centered on the ROSAT error circle. Near the west edge of this circle we note the two objects labelled A and B that are completely invisible on a V image (Figure 2b) with limiting magnitude of approximately 24.5 obtained the same night as the I frame in Figure 1. These objects are also invisible at B and U with limiting magnitudes of $\sim$ 24.0 and $\sim$ 23.0, respectively. The photometric VIJHK measures of objects A and B (accurate to $\sim$ 0.05 mag) are listed in Table I.

TABLE I
Summary of Optical/Near IR Photometry

Object	V	I	J	H	K
A	>24.5	18.13	9.31	7.12	6.10
B	>24.5	18.30	9.69	7.68	6.69

In Figure 3 we show the H−K *vs.* J−H near IR color-color diagram for all stars detected on the JHK frames. The solid line shows the locus of unreddened main-sequence colors, and the dashed lines enclose the region populated by reddened main sequence stars. The corresponding loci for giants are quite similar, and are not displayed. From this Figure, it is clear that objects A and B have colors consistent with heavily reddened ordinary stars.

Spectroscopic observations obtained with the Hale 5-m telescope of objects A and B are shown in Figure 4. The features of both spectra in the 600−900 nm region are consistent with a spectral type of early M, though the optical and near-IR colors indicate again that, if they indeed are M stars, they are heavily reddened.

3. IRAS Source

The IRAS point-source catalog lists a source exactly at the position of the object AB pair (to within the errors of the position), with 12, 25, 60 and 100 μm fluxes of 3.1, 5.8, 9.2 and 38.2 Jy, respectively.

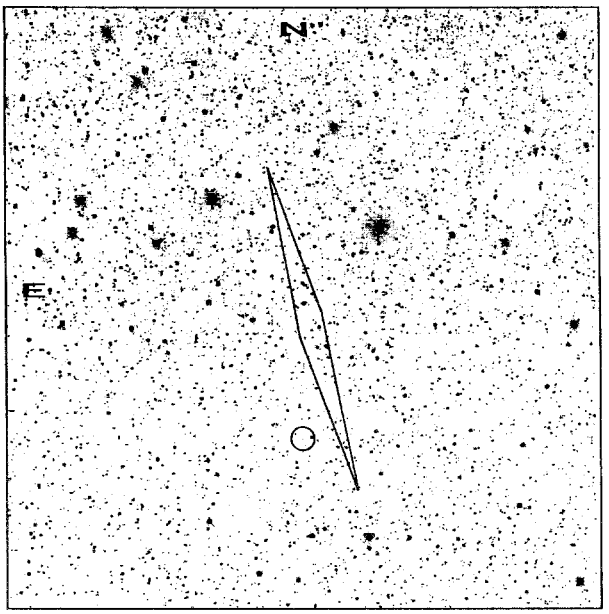

Fig. 1. Field showing the NST and ROSAT localizations. The frame is 23 arcminutes across.

4. Discussion

The optical and IR fluxes for the pair of objects described here are not consistent with an object of single characteristic temperature. The visible and near-IR data are consistent with an extremely reddened stellar photosphere of about spectral class M3, but the increasing flux in the far-IR shows that there is a cooler component involved as well. If we assume that the underlying photosphere is of an M3 dwarf, that the J-H color is uncontaminated by whatever is causing the far IR excess, and a normal interstellar reddening law, the total extinction in the visible region would be about 21 magnitudes. This is consistent with the non-detection of the objects at V.

Kulkarni *et al.* (1995) have reported the discovery of a red stellar object very close to the center of the SNR associated with the SGR B1806−20, which they interpret to be a highly reddened ($A_V \simeq 30$ mags.) supergiant star of spectral class earlier than late G/early K. Though this object is apparently single, the similarity to the objects A and B described here is striking.

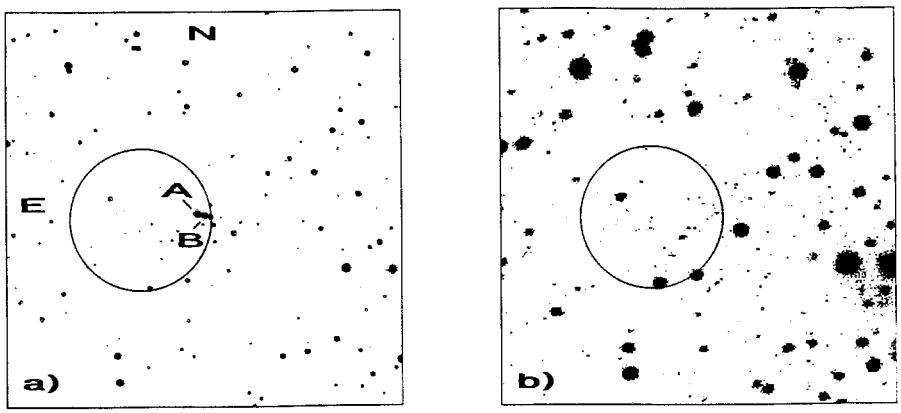

Fig. 2. I (a) and V (b) frames showing the ROSAT localization and stellar objects A and B discussed in the text..

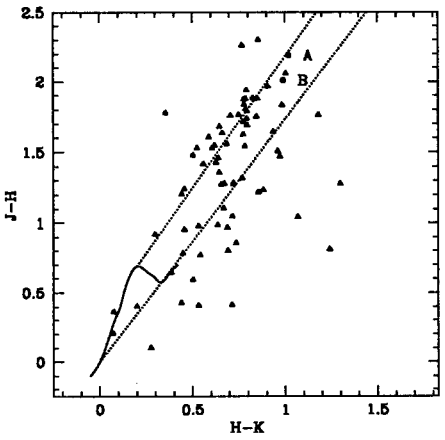

Fig. 3. H−K *vs.* J−H near-IR color-color diagram for sources near the ROSAT position.

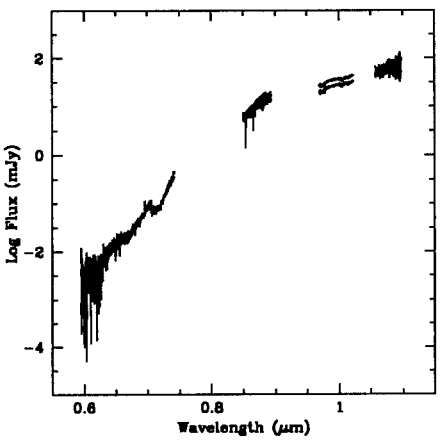

Fig. 4. Spectra for objects A (upper) and B (lower).

References

Cline *et al.*: 1982, *Astrophys. J.* **255**, L45.
Hurley *et al.*: 1994, *Astrophys. J.* **431**, L31.
Kouveliotou, C. *et al.*: 1993, *Nature* **362**, 728.
Kulkarni, S.R. and Frail, D.A.: 1993, *Nature* **365**, 33.
Kulkarni, S.R. *et al.*: 1995, *Astrophys. J.* **440**, L61.
Vashisht, G., Kulkarni, S.R., Frail, D.A. and Greiner, J.: 1994, *Astrophys. J.* **431**, L35.